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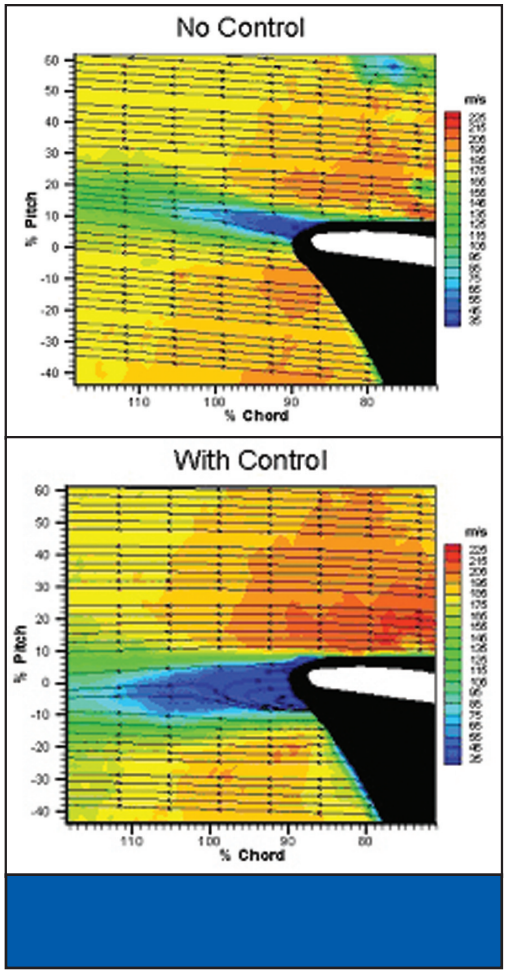
Success Story

PROPULSION DIRECTORATE ACHIEVES NON-MECHANICAL CASCADE AIRFLOW VECTORING



Scientists from the Propulsion Directorate's Fan and Compressor Branch, in collaboration with Virginia Polytechnic Institute and State University (Virginia Tech), demonstrated an airflow control technique with application to future compressor designs. This technique, if successfully applied to future turbine engines, should reduce the number of engine parts, significantly lower overall engine weight, and reduce overall engine cost.

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Accomplishment

The directorate and Virginia Tech team demonstrated the first-ever counter-flow-blowing-based flow vectoring in a high through-flow Mach number stator cascade. Virginia Tech tested the cascade in their "blow-down wind tunnel" facility as part of this collaborative effort. By placing a blowing jet on the pressure side surface of the cascade blade near the trailing edge, researchers vectored the passing airflow and provided flow control without mechanical parts.

Background

Current jet engine fan designs, in many cases, require flapped inlet guide vanes and variable stators to ensure correct inlet flow conditions during off-design operation. Every stator blade in the compressor section must be coupled mechanically to all other stator vanes in a stage and then, in turn, to an actuating mechanism. This is a complex and heavy aspect of current compressors.

Through these connections, research engineers can change stator blade angle-of-attack (relative to incoming air) to control engine airflow. The ability to vector the flow without the need for this mechanical complexity reduces both the number of parts and overall weight of the compressor.

Instead of a complex mechanism to vector the airflow in the test cascade, directorate scientists employed blade pressure side surface counter-flow "blowing" to increase blade circulation and achieve considerable flow vectoring. Increasing the circulation increases the pressure distribution on the stator and turns the airflow.

For this demonstration, directorate engineers placed the blowing jet on the pressure surface of the blade near the trailing edge and directed it into the main flow direction, that is, a counter-flow direction. The engineers directed the blowing as tangent to the blade surface as possible.

The results of this technique, as illustrated in the photos, clearly demonstrate that the blowing caused an increase in the amount of flow turning from the baseline. Directorate engineers achieved this result in the test by counter-flow blowing at a level of 1% of the air passing through the cascade.

When measured using the particle image velocimetry technique, this 1% case resulted in a 9° flow turning. Based on these results, the directorate anticipates achieving even greater levels of flow vectoring, leading to higher efficiency and lower weight compressor designs.

Propulsion
Emerging Technologies

Additional information

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